DISSOLUTION ASSOCIATED WITH SIMULATED PHYSICAL WEATHERING OF LUNAR BRECCIA 79135. R. E. Beiersdorfer[1], D. W. Ming[2], C. Galindo[3], D. C. Golden[4] S. J. Wentworth[5] and D. S. McKay[2], [1]Department of Geology, Youngstown State University, Youngstown, OH 44555, ray@cc.ysu.edu, [2]NASA Johnson Space Center, Houston, TX 77058, [3]Hernandez Engineering Inc., 17625 El Camino Real, Houston, TX 77058, [4]Dual Inc., Houston, TX 77058, [5]Lockheed Martin NASA Johnson Space Center, Houston, TX 77058.

Processing of lunar materials will be an essential aspect of a long-duration space mission to the Moon. Simulated physical and chemical weathering of lunar materials may produce a "soil" capable of providing a solid support substrate for plant growth as well as a source of essential plant-growth nutrients (e.g. see Ming and Henninger, 1988). However, very limited information is available on how lunar materials will react when placed in a weathering or Earth-like environment (e.g. soils for plant growth). Therefore, we have examined the composition of a solution in contact with lunar breccia 79135.

Lunar sample 79135 is a dark matrix "soil" breccia collected on the flank of the Sculptured Hills (northern part of the Taurus-Littrow Valley) during the Apollo 17 mission (AFGIT, 1973). It has been classified as a North Massif type soil by Rhodes and others (1974). Physical weathering of lunar sample 79135 was accomplished by placing ~ 0.5 grams of solid in contact with ~ 2 ml of H_2O. The sample/water mixture was contained in three Teflon bags (each bag was heat sealed) and subjected to 27,144 freeze/thaw cycles. 1.4 ml of solution was extracted and filtered through a 0.45 micron filter to separate the solution from any breccia material in suspension. The solution was diluted 1:2 with deionized water and analyzed for Al, Si, Ti, Mn, Fe, Cu and Zn by Graphite Furnace Atomic Absorption Spectroscopy (see Table 1). Other major elements (Mg, Ca, Na, K, P, S, Cr) reported by Rhodes and others (1974) to be present in lunar sample 79135 were not measured.

Measured pH of the extracted solution is 6.23. Measured conductivity is 212.0 micro mhos per centimeter, which can be used to calculate an Ionic strength of 2.69E-3 using the empirical relationship of Griffin and Jurinak (1973).

The geochemical equilibrium speciation program MinteqA2 (Allison, et al., 1991) was used to determine the dominant species of each measured element. With the exception of Al, each element is predicted to occur as a single species: Si as H_4SiO_4; Mn as Mn^{2+}; Fe as Fe^{2+}; Cu as Cu^{2+} and Zn as Zn^{2+}. Al was predicted to occur as four species: 1) $AlOH^{2+}$ (34.8%); 2) Al^{3+} (31.5%); 3) $Al(OH)_2$ (29.6%) and 4) $Al(OH)_3$ aq (4.1%). The results of the MinteqA2 run also indicate that the solution is supersaturated with the Al-bearing phases boehmite, diaspore and gibbsite.

The results of the dissolution of Apollo 12 sample 12070,128 at room temperature in deionized water by Keller and Huang (1971) are shown in Table 2. Three elements are common to both studies (Al, Si, Fe) and occur in similar concentrations in the starting material (compare Tables 1 and 2). Al dissolution is significantly greater when the sample undergoes simulated mechanical weathering (this study) in contrast to being placed in contact with deionized water at room temperature (Keller and Huang, 1971). The opposite is true for Si. The amount of Fe dissolution reported by Keller and Huang (1971) is double that reported in this study. The pH reported by Keller and Huang (1971) range from 5.65 at eight hours to 7.38 at eighty-one days and most likely reflect equilibration of the water with atmospheric CO_2 as well as changes due to dissolution.

The results of this study indicate that the essential plant micro-nutrients Mn, Fe, Cu and Zn could be made available to plants via the dissolution accompanying simulated mechanical weathering. The composition of lunar soils and the dissolution properties of lunar breccia 79135 indicate that a lunar soil has the potential to be a good medium for the growth of plants at future lunar outposts.

Table 1: Concentrations of select elements in lunar sample 79135 and their concentration in solution after simulated mechanical weathering.

Elem.	Solid Conc. (wt % oxides)	Solution Conc. (ppb)
Ref.	(Rhodes et al., 1974)	(this study)
Al	15.08	228.9
Si	42.29	232.3
Ti	5.15	0.00
Mn	0.19	10.5
Fe	14.01	14.3
Cu	n.a.	4.23
Zn	72 ppm	0.86

Table 2: Concentrations of select elements in lunar sample 12070,128 and their concentration in solution after dissolution in deionized water open to the atmosphere. Solid concentrations are from Table 1 of Keller and Huang (1971); solution concentrations are calculated from Figure 1 of Keller and Huang (1971).

Elem.	Solid Conc. (wt % oxides)	Solution Conc. (ppb)
Na	0.5	114.9
Mg	10.7	486.1
Al	13.0	27.0
Si	45.9	1404.3
K	0.23	19.5
Ca	10.4	1202.4
Fe	16.4	27.9

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